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Land-mammals from the Late Paleocene Aquia Formation: The first early Cenozoic mammals from Maryland

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Abstract.—The late Paleocene Aquia Formation has produced the first early Cenozoic mammal remains from Maryland: a molar of the taeniodont *Ectoganus*, a molar fragment questionably referred to the condylarth *Phenacodus*, and an ungual phalanx of an arctocyonid. They constitute only the third record of Paleocene mammals from eastern North America.

Paleocene mammals are almost unknown from North America east of the Western Interior. Only two such occurrences have previously been reported, one in Louisiana and the other in South Carolina. The first was the highly improbable discovery of a snout and palatal dentition of a Torrejonian anisonchine condylarth, found in a well-core taken at a depth of more than 2400 feet, in Caddo Parish, Louisiana (Simpson 1932). The second is a small collection of late Paleocene mammal fragments recovered from spoil heaps of the Williamsburg Formation, Black Mingo Group, in Berkeley County, South Carolina (Schoch 1985, 1998). In view of this meager record, it is deemed worthwhile to report here a third record of Paleocene mammals from the eastern part of the continent, and the first from Maryland.

Occurrence and Age

The three specimens of the present report come from bluffs along the eastern shore of the Potomac River, about 0.25–0.60 mile north (where the bluff is called the Blue Banks) and about 0.25 mile south of Douglas Point, 3 miles west of Nanjemoy, Charles County, Maryland (Fig. 1; USGS Widewater 7.5-minute Quadrangle). In those areas the exposures are Paleocene, whereas the bluff immediately north and south of Douglas Point is Pleistocene (G. J. Grimsley & R. E. Weems, pers. comm.). The fossils are from the shallow marine Piscataway Member of the Aquia Formation (Pamunkey Group), which is bracketed within calcareous nannoplankton zones upper NP5-NP8 (Ward & Wiest 1990, Gibson et al. 1991). This corresponds approximately to late Paleocene magnetochrons upper C26r to C25n, spanning roughly 60 to 56 Ma (Berggren et al. 1995, Cande & Kent 1995). According to Olson (1994) and Weems (pers. comm.), the vertebrate-producing zone is in the lower part of this sequence (NP5 or 6), which is approximately equivalent to the middle Tiffanian land-mammal age (Fig. 2; see also Woodburne & Swisher 1995). The Piscataway Member consists of shelly glauconitic sands deposited in an offshore shallow shelf environment, and has produced a diverse fauna of sharks, rays, and bony fishes, as well as two crocodilians and a variety of mainly marine turtles (Weems 1988 and pers. comm., Ward & Wiest 1990). Rare avian fossils are also known, including a pelecaniform and a new species of *Presbyornis* (Olson 1994). Most or all of these remains represent marine or ocean-loving species. Remains of terrestrial vertebrates are rare.

Above the Aquia Formation in northeastern Virginia, the early Eocene Potapaco Member of the Nanjemoy Formation (also

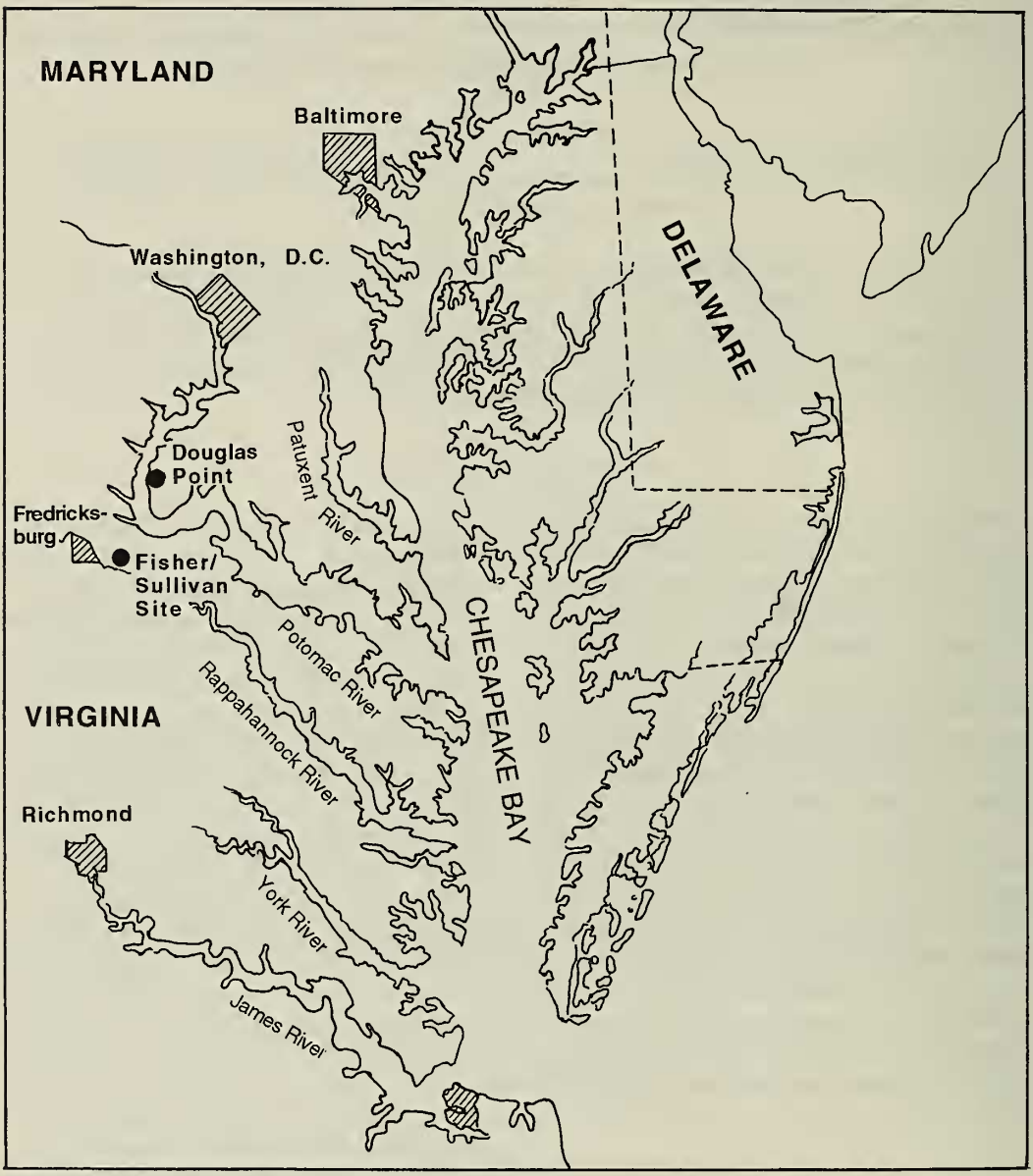

Fig. 1. Location map of late Paleocene Aquia Formation exposures at Douglas Point, Charles County, Maryland. Also shown is early Eocene Fisher/Sullivan Site east of Fredericksburg, Virginia.

Pamunkey Group) has produced a diverse early Eocene vertebrate assemblage (Fisher/ Sullivan Site: Weems & Grimsley 1999a; see Fig. 1), including the first early Eocene land-mammals from the central east coast of North America (Rose 1999). The Potapaco Member consists of bioturbated glauconitic sands and clays deposited in neritic environments, similar to the Piscataway Member of the Aquia (Gibson et al. 1991).

The three very fragmentary mammal specimens described here represent three separate discoveries made over a quarter of a century. Two of the specimens were found in situ in the bluffs, while the third was recovered from beach drift.

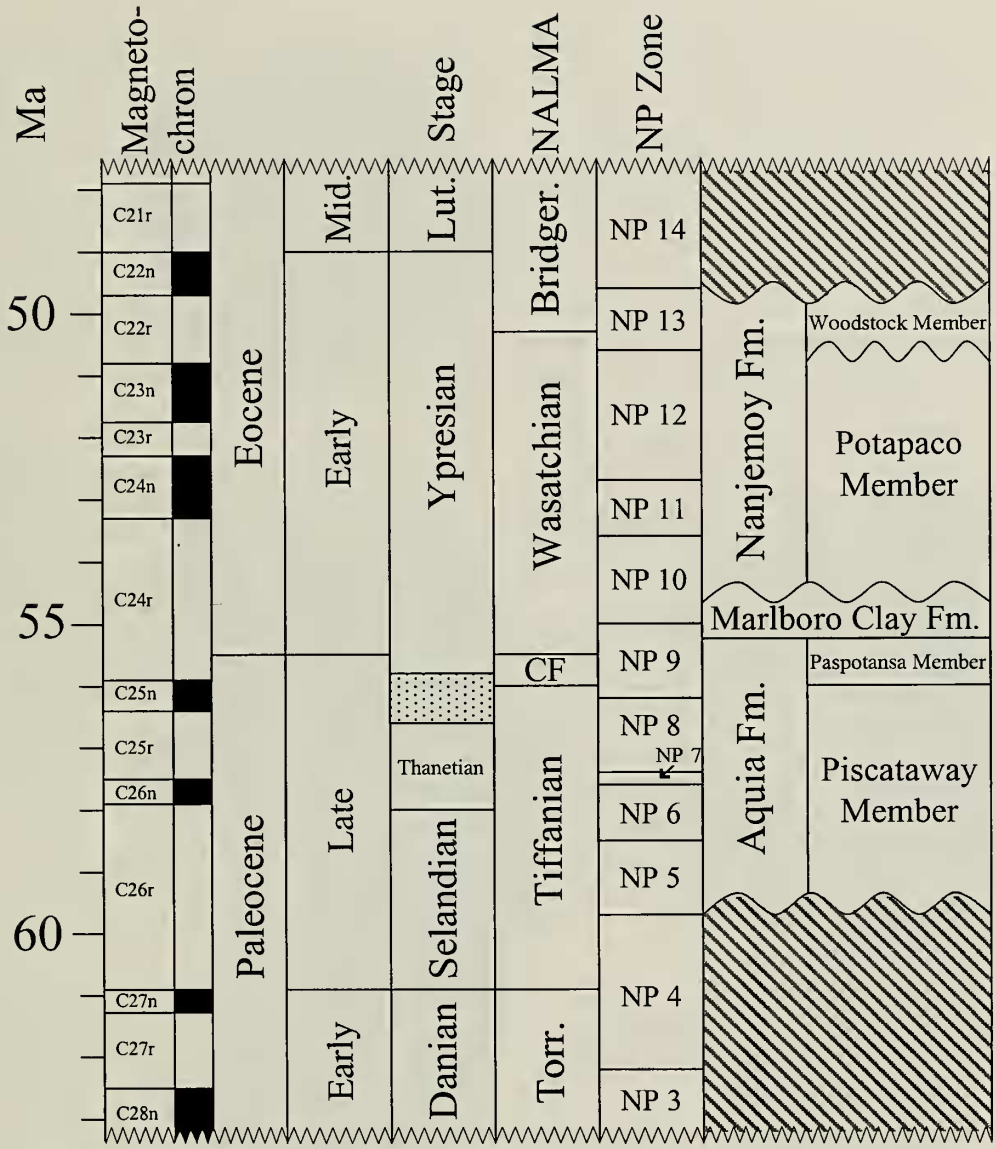

Fig. 2. Stratigraphic and chronologic correlation of the Aquia and Nanjemoy formations relative to magnetochrons, epochs, stages, North American Land-Mammal Ages (NALMAs), and nannoplankton zones. Compiled, with minor modifications, after Ward & Wiest (1990), Gibson et al. (1991), Berggren et al. (1995), Cande & Kent (1995), McKenna & Bell (1997), Berggren & Aubry (1998), and Weems & Grimsley (1999b). Paleocene-Eocene boundary correlations are based mainly on Berggren & Aubry (1998).

Abbreviations used are: ChM–Charleston Museum, Charleston, South Carolina; USNM—Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Order Taeniodonta
Family Stylinodontidae
Ectoganus cf. *gliriformis* Cope, 1874
Fig. 3

Referred specimen.—USNM 495534, right m1?; found in situ at beach level about

0.5 mile north of Douglas Point. Collected by R. Harding and G. J. Grimsley, 1999.

Description.—This little-worn, high-crowned taeniodont tooth is very similar to m1 of *Ectoganus* from Wyoming. It is slightly smaller than the specimen of *E. gliriformis* (a p4) from the Black Mingo Group, and differs in having the metaconid slightly higher than the protoconid, and a well-developed talonid with the entoconid as high as the hypoconid (features suggesting it is a molar). In addition, it has a small hypoconulid, two small entoconulids, and a low median paraconid (or anterior cingulid?), all features typical of *E. gliriformis* (Schoch 1986). Dimensions of the tooth are: length = 11.7 mm, trigonid width = 12.0 mm, talonid width = 10.5 mm (all maximum dimensions).

The tooth is also very similar in size and crown morphology to molars of *Psittacotherium multifragum* (e.g., USNM 15417) from the Torrejonian of the San Juan Basin, but differs in being much higher crowned (a characteristic of *Ectoganus*). *Ectoganus gliriformis* is a late Paleocene-early Eocene (late Tiffanian-Wasatchian) species otherwise known from New Mexico, Colorado, Wyoming, and southern Montana, as well as South Carolina.

Order Procreodi (=Arctocyonia)
Family Arctocyonidae, indeterminate
Fig. 4

Referred specimen.—USNM 446999, ungual phalanx; found at beach level in the Blue Banks, north of Douglas Point. Collected by C. F. Allison, Jr., 1974.

Description.—This ungual phalanx is relatively large and morphologically distinctive. It is robust, curved, and only slightly laterally compressed. The proximal articular surface is dorsoventrally concave, slightly higher than wide, and tapered dorsally, with a low sagittal keel separating paired surfaces that articulated with the intermediate phalanx. The ungual shaft is similarly wider ventrally and tapered dorsally, forming a rounded crest along the median dorsal margin, which is shallowly fissured along its distal third. The proximodorsal margin is slightly extended into a weak extensor tubercle. Ventrally, the very prominent flexor tubercle (where the deep digital flexors inserted) is wider than the ungual shaft and gently convex on its plantar aspect. Faint neurovascular grooves run distodorsally from the tubercle toward the tip; near the tip a vascular (or neurovascular) canal opens on each side just below the groove.

In all these details the phalanx closely resembles the ungual phalanges of the large Paleocene arctocyonids *Arctocyon* and *Claenodon* (Matthew 1937, Russell 1964) and their early Eocene relative *Anacodon* (Rose 1990). Though slightly damaged at the tip, it is virtually complete. It measures 23.2 mm long and is 6.3 mm wide at midlength. The proximal articulation is 11.7 mm in dorsoventral dimension (excluding the flexor tubercle) and 10.7 mm at its widest point.

Order Condylarthra
Family ?Phenacodontidae
?*Phenacodus* sp.
Fig. 5

Referred specimen.—USNM 495535, talonid of left m1 or m2; found in beach drift about 0.25 mile south of Douglas Point. Collected by E. Supensky, 1999.

Description.—This heavily abraded molar fragment shows evidence of heavy wear during life, as well as significant postmortem hydraulic abrasion. A scar on the anterior surface indicates where the trigonid has been broken away. The remaining talonid measures 8.0 mm wide and 6.0 mm long, which is at the small end of the size range of the Tiffanian species *Phenacodus grangeri* (Thewissen 1990). The tooth bears a stout root which, from the distal aspect, is divided only at the tip of the roots, but in mesial view consists of two separate roots. The crown is worn nearly flat, with margins and

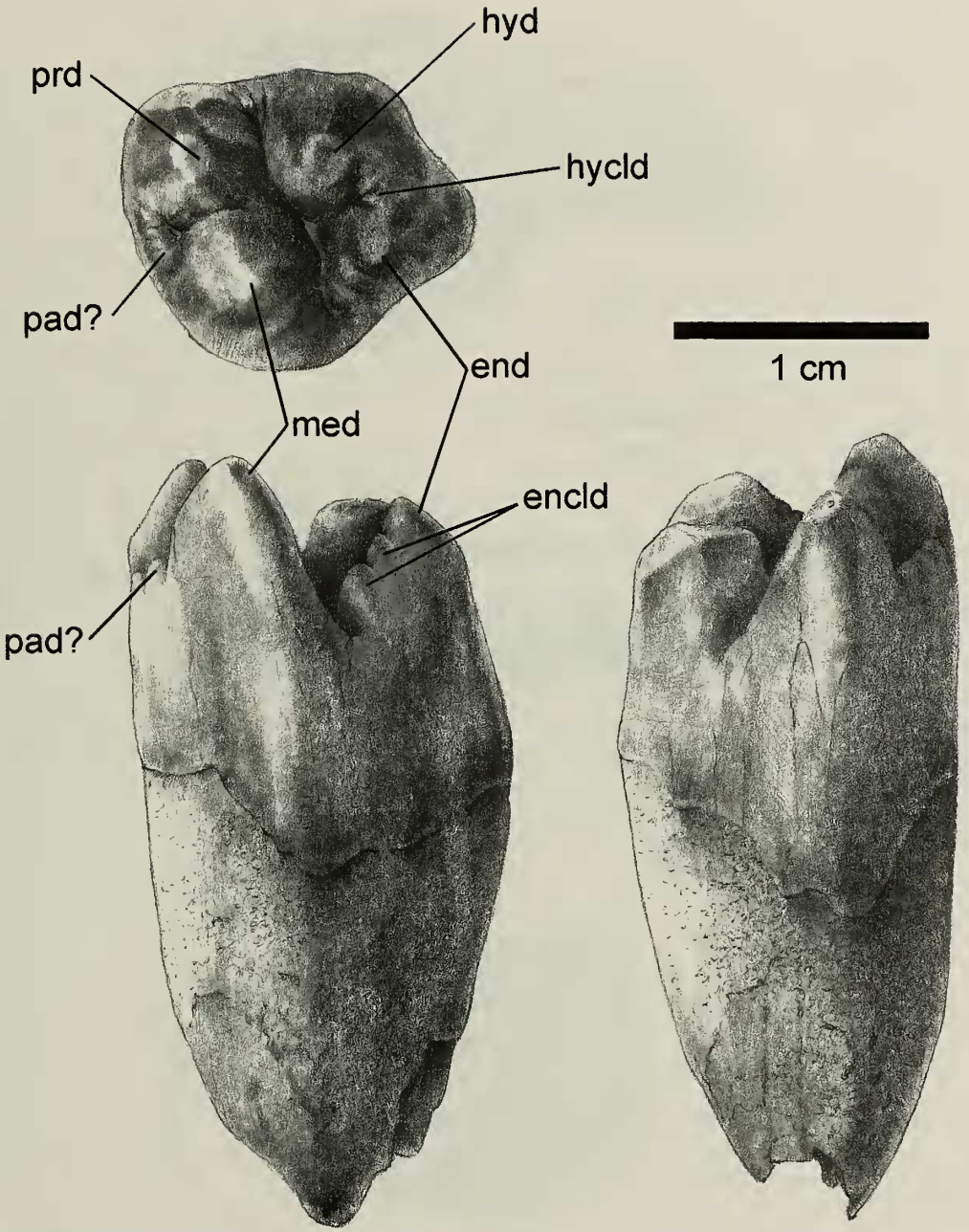

Fig. 3. *Ectoganus* cf. *gliriformis*, right m1? (USNM 495534), in crown view (above) and oblique lingual (left) and buccal views. Abbreviations: encld–entoconulid; end–entoconid; hycld–hypoconulid; hyd–hypoconid; med–metaconid; pad–paraconid; prd–protoconid.

islands of polished enamel separated by dentine windows. The wear pattern approximates that of heavily worn *Phenacodus* molars more closely than that of any other taxon compared. Areas apparently corresponding to large hypoconid and entoconid cusps, a smaller, median hypoconulid, and the cristid obliqua can be identified.

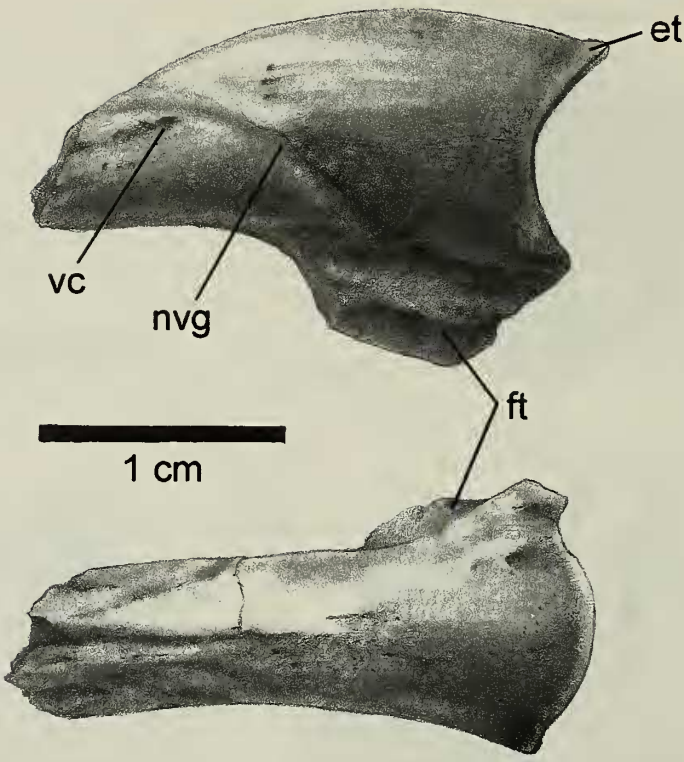

Fig. 4. Arctocyonid ungual phalanx (USNM 446999), in lateral and dorsal views. Abbreviations: et–extensor tubercle; ft–flexor tubercle; nvg–neurovascular groove; vc–vascular or neurovascular canal.

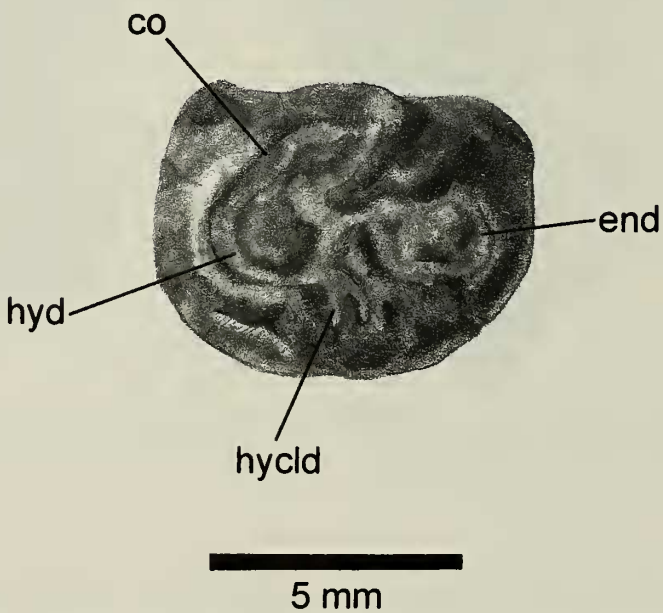

Fig. 5. ?*Phenacodus* sp., talonid of left m1 or m2 (USNM 495535), in crown view. Abbreviations: co–cristid obliqua; end–entoconid; hycld–hypoconulid; hyd–hypoconid.

Discussion

The Aquia mammal specimens provide the first record of Paleocene mammals from Maryland. Because of their imprecise identification, they are not significant chronological indicators, but they are consistent with a late Paleocene age for the Piscataway Member. The taeniodont *Ectoganus* is otherwise known primarily from the Clarkforkian and Wasatchian of Wyoming. Only specimens from the late Tiffanian of the Plateau Valley local fauna, Wasatch Formation of Colorado, and the late Paleocene Black Mingo Group of South Carolina are probably older than the Wyoming material (Schoch 1986), but neither appears to be as old as nannoplankton zones NP5 or NP6, the age suggested for the Piscataway Member. The Black Mingo assemblage is thought to date from nannoplankton zones NP8 or NP9 (Weems & Bybell 1998); Schoch (1998) considered it to be of probable Clarkforkian age. Thus, the Aquia *Ectoganus* appears to be older than any other record of the genus, extending its range well down into the Tiffanian. *Phenacodus* is known from the late Paleocene into the early middle Eocene (Tiffanian-Bridgerian) in the Western Interior, and from the early-middle Eocene of Europe (Thewissen 1990). As mentioned above, large arctocyonids comparable to the one represented in the Aquia Formation are also known from both Paleocene and early Eocene beds (late Torrejonian-Wasatchian of North America, Thanetian of Europe).

It seems a remarkable coincidence that of the few Paleocene mammal specimens known from the Black Mingo Group and the Aquia Formation, the otherwise rare taeniodont *Ectoganus* occurs in both. It is tempting, though probably premature, to speculate that the east coast provided environments favorable to taeniodonts. The Black Mingo and Aquia assemblages may also share the common condylarth genus *Phenacodus*. Large arctocyonids, such as the one represented by the Aquia ungual, were not previously known from the early Cenozoic of eastern North America, although they are present in coeval strata of both the Western Interior of North America and western Europe.

The Black Mingo assemblage includes two other significant mammal specimens, each representing bizarre and distinctive taxa (Schoch 1985). An unidentified tribosphenidan molar talonid (ChM PV2927) is peculiar in presenting a broad, lingually open talonid basin flanked by a lingually directed cristid obliqua (creating a deep hypoflexid) and a straight postcristid that ends in a prominent entoconid. A fracture at the mesial end of the cristid obliqua suggests the former presence of a metastylid. These traits are reminiscent of the late Paleocene-early Eocene condylarth *Meniscotherium*, though the Black Mingo talonid differs in being relatively longer and in lacking an entoconulid, which is often but not invariably present in *Meniscotherium*. The other Black Mingo mammal is a previously unknown form for which Schoch (1985) proposed the name *Mingotherium holtae*. He referred it questionably to the Uintatheriamorpha. The single known upper molar (ChM PV4113) shares with uintatheres a tall protocone and similar wear on the protocone crests; but the paracone and metacone are bunodont and of comparable size, and the postprotocrista does not meet the metacone. These conditions are quite unlike those of uintatheres, in which the paracone is larger than the metacone and both are rather acute, and the paraloph and metaloph run to paracone and metacone respectively, forming a distinct V-shape pattern. Schoch (1985) also compared *Mingotherium* with the Paleocene Asian genus *Pseudictops*, currently placed in the Anagalida (McKenna & Bell 1997), and the same similarities and differences apply to that comparison. Both *Mingotherium* and *Pseudictops* also have well-developed pre- and postcingula on the upper molars. Consequently, McKenna & Bell (1997) included *Mingotherium* within the family Pseudictopidae (thus extending the

range of this otherwise Asian family into eastern North America), although Lucas & Schoch (1998) left it as Eutheria incertae sedis. It is also noteworthy that the tall protocone and bunodont paracone and metacone of *Mingotherium* are reminiscent of conoryctine taeniodonts, but the high and prominent pre- and postcingula are unlike taeniodonts. Whether resemblances to any of these groups reflect true relationship or merely convergence will require more substantial evidence than a single tooth. In the meantime, the phylogenetic position of *Mingotherium* will likely remain problematic.

The small glimpse of east coast Paleocene mammalian faunas afforded by the Aquia and Black Mingo assemblages suggests that this region held some taxa in common with contemporary Rocky Mountain faunas, but that the overall composition of east coast faunas may have been rather different. Only with additional samples will it be possible to assess the provinciality of east coast Paleocene faunas.

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